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**U1S** S1144 S1206 S1213 S1704 S1820 S1839 S3011

(56) Documents Cited
**US 4372997 A**

(58) Field of Search
UK CL (Edition ) **B5N**
INT CL$^6$ **B32B 5/24 5/26 5/28 7/12 27/04 27/18 27/20 27/24**
**ONLINE:WPI,CLAIMS**

# (54) A fabric which is fire and heat resistant

(57) A fabric (2) which is fire and heat resistant comprises a laminate of first and second sheets of material (4, 6) which have been separately formed and then connected together, the first and the second sheets of material (4, 6) each comprising a mixture of an organic intumescent filler and an adhesive which has been applied to a first side (8) of each of the sheets of material (4, 6) in liquid form such that the liquid mixture penetrates partially into each of the sheets of material (4, 6) from the first side (8) and on drying provides each of the sheets of material (4, 6) with an inner layer (10) formed of just the mixture, an intermediate layer (12) formed of that part of the sheet of material that has been penetrated by the mixture, and an outer layer (14) formed of that part of the sheet of material that has not been penetrated by the mixture, the fabric (2) being such that the first and the second sheets of material (4, 6) are positioned with the inner layers (10) touching each other, and the inner layers (10) being at least partially connected together by the adhesive in the mixture.

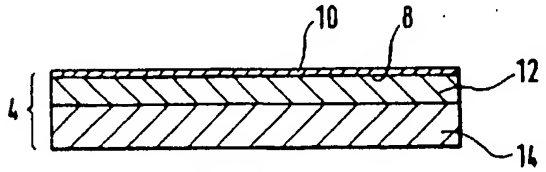


Fig.1.

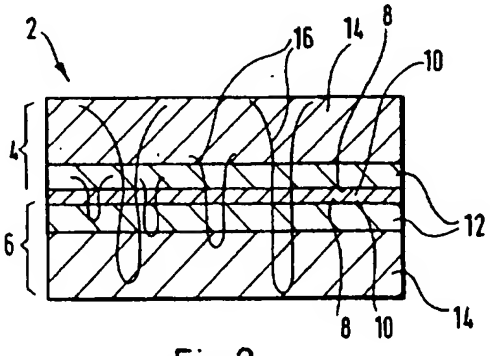


Fig.2.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1995

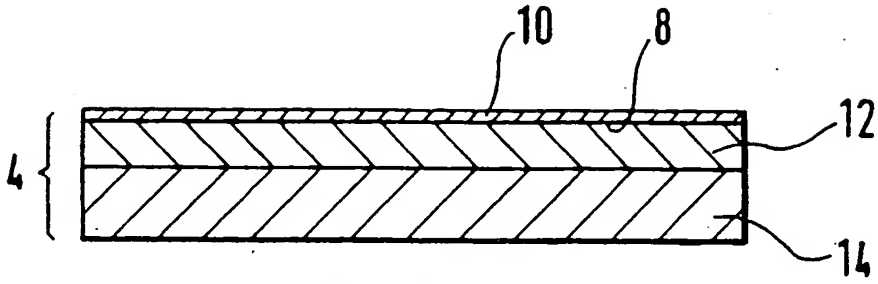


Fig.1.

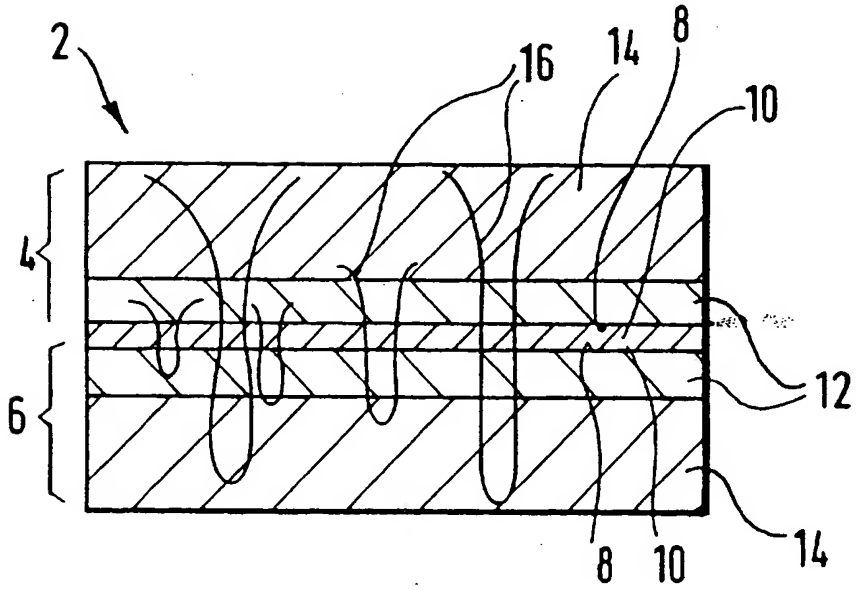


Fig.2.

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# A FABRIC WHICH IS FIRE AND HEAT RESISTANT

This invention relates to a fabric which is fire and heat resistant.

Fabrics which are fire and heat resistant are well known. The fabrics have many uses including forming protective clothing, furnishings and upholstery coverings.

Patent specification WO 93/18824 discloses a fabric which is fire and heat resistant and which comprises an intimate mixture of an organic intumescent filler and organic fibres which are adapted to char within the temperature range of 200-500°C, the charring being such that carbonising reactions dominate the thermal degradation that occurs in the organic fibre components. WO 93/18823 discloses various methods of producing the fabric but none of these methods are suited as a practical matter for producing the fabric on a commercial scale.

It is an aim of the present invention to provide a fabric which is fire and heat resistant, which includes an organic intumescent filler, and which is of a construction which enables the fabric easily to be produced on a commercial scale.

Accordingly, in one non-limiting embodiment of the present invention, there is provided a fabric which is

fire and heat resistant and which comprises a laminate of first and second sheets of material which have been separately formed and then connected together, the first and the second sheets of material each comprising a mixture of an organic intumescent filler and an adhesive which has been applied to a first side of each of the sheets of material in liquid form such that the liquid mixture penetrates partially into each of the sheets of material from the first side and on drying provides each of the sheets of material with an inner layer formed of just the mixture, an intermediate layer formed of that part of the sheet of material that has been penetrated by the mixture, and an outer layer formed of that part of the sheet of material that has not been penetrated by the mixture, the fabric being such that the first and the second sheets of material are positioned with the inner layers touching each other, and the inner layers being at least partially connected together by the adhesive in the mixture.

The use of the liquid mixture of the organic intumescent filler and the adhesive on the first side of the sheets of material advantageously enables the organic intumescent filler to be locked into the fabric when the sheets of material are connected together with the inner layers touching each other. The organic intumescent filler is able to be used without creating

too much dust and waste. This enables the fabric of the present invention to be produced at an economical price, helping to satisfy legislation which requires the use of fire and heat resistant fabrics in a large number of areas, and helping to satisfy industry which is required by the legislation to use these fabrics but does not want the fabrics if they are substantially more expensive than previously used fabrics which are not fire and heat resistant. The use of the liquid mixture also enables good control to be achieved over the amount of the organic intumescent filler used, as compared to random mixing. The locking of the organic intumescent filler in the centre of the fabric and the use of the adhesive helps to ensure that the organic intumescent filler does not fall out of the fabric when the fabric is used and it starts to wear and become torn. If a dry powder mixture of the organic intumescent filler and the adhesive were to be placed on a sheet of material and then needling were to be employed to consolidate the dry powder into the fabric, then an unacceptable amount of dust would be created and this is bad for the health and safety of employees.

With the fabric of the present invention, there is no need to try and cover the fabric with layers of other material in order to try and contain the organic intumescent filler. Thus, whilst other layers of

material may be employed if a particular type of fabric is required, these other layers of material are not essential and thus the cost of the fabric of the present invention can be kept to a minimum. The first and the second sheets of material can be chosen in dependence upon the final intended use of the fabric of the invention. Thus the first and the second sheets of material can be chosen to give desired wear characteristics and/or desired feel characteristics and/or desired colour characteristics.

The use of the adhesive enables the inner layers to be connected together so that, with the appropriate type of adhesive, a pressure sensitive tack effect may be obtained.

It is preferred that the first and the second sheets of material are needled to supplement the connection made by the adhesive. The needling, which is preferably a light needling, tends to add a firmer bond to the first and the second sheets of material than when only the adhesive is used.

The fabric is preferably one in which the first and the second sheets of material are formed of organic fibres which are such that they char within the temperature range of 100-500$^{o}$C, the charring being such that carbonising reactions dominate the thermal degradation that occurs in the organic fibre components.

Preferably the organic fibres are such that they char as aforesaid within the temperature range of 200-500°C.

The organic fibres are preferably such that they are flame-retarded organic fibres, or such that they release a flame-retardant on being heated. The organic fibres may comprises a flame-retarded cotton viscose or wool fibre.

As the organic fibres char, wetting of fibre surfaces occurs by liquid acidic species generated from the flame retardant and/or any other acid-generating species in the organic fibres and/or from acidic products from the heated organic intumescent filler. This results in the charred surfaces of the fibres and the organic intumescent filler bonding together to produce a fibre-reinforced amorphous intumescent char structure having all the advantages of an intumescent filler as far as fire and heat resistance are concerned, but without the disadvantages of inflexibility and brittleness normally associated with organic intumescent fillers.

Preferably, the first and the second sheet of material are non-woven fabrics structures. If desired however the first and the second sheets of material may be woven, knitted or other fabric structures. The first and the second sheets of material will usually be the

same sheets of material but different types of first and second sheets of material may be employed if desired.

The fabric of the present invention may include an inorganic fibre component. The inorganic fibre component may be formed of inorganic fibres which are mixed with the organic fibres. Alternatively, the inorganic fibre component may be formed by a hybrid fibre which contains both organic and inorganic components.

The inorganic fibre component may have a melting point at temperatures significantly higher than 500°C. The inorganic fibre component may be effective to assist the action of the organic intumescent filler to further delay complete oxidation of residual carbon from the char resulting from exposure of the fabric to fire and heat. The inorganic fibre component may help to create a skeletal structure which provides the fabric with a thermally insulated property even after all the carbonaceous materials in the fabric have been converted into gases.

A presently preferred hybrid organic fibre containing organic and inorganic components is a viscose staple fibre containing silicic acid and sold under the trade mark VISIL by Kemira Group Oy of Valkeakoski, Finland. In the fabric of the present invention, the

VISIL fibres may provide a fire and heat resistant structure up to 1200°C.

Where the fibres are treated with a flame retardant material, then a presently preferred flame retardant material is that sold under the trade mark PROBAN by Albright and Wilson.

The fabric of the present invention is able to form a responsive barrier fabric. The fabric may be used directly as a barrier material. Alternatively, the fabric may be used as a backing layer, a facing layer or an intermediate layer, all in any suitable and appropriate products. The backing and/or facing layers may be flexible layers, or they may be rigid layers formed of, for example, wood or metals, including metal foils such for example as aluminium foils. Where facing and/or backing layers are employed, then these facing and/or backing layers may be used to provide physical and/or mechanical characteristics for the product, in addition to contributing aesthetic characteristics if desired. The layer or layers may also serve to form the product to a required shape.

The fabric of the present invention may have a relatively low area density. This may enable the fabric to be used in the transport industry, for example in road vehicles and aircraft, where weight is an important consideration. Generally, any of the conventional

techniques of fabric production may be employed to produce the fabric of the present invention, including weaving, knitting, needle punching, stitch bonding and adhesive bonding.

Any suitable and appropriate organic intumescent material may be employed. The organic intumescent material may comprise an acid source, a carbonific material, a spumific compound, and a skin-forming soft resin binder to prevent the escape of generated gases from the organic intumescent filler. The acid source may be, for example, mono- and di-ammonium phosphates, ammonium polyphosphates, melamine phosphate, guanyl phosphate, urea phosphate, ammonium sulphate and ammonium borate. The carbonific material may be glucose, maltose, arabinose, erythritol, pentaerythritol, di- and tri-pentaerythritol, arabitol, sorbitol, insitol and starches. The spumific compound may be, for example, melamine, guanidine, glycine, urea and chlorinated paraffin. Any suitable and appropriate soft resin binders may be employed.

Preferably, the first and the second sheets of material contain cellulose-based organic fibres, together with a phosphorus-based flame retardant such for example as Proban, Pyrovatex or ammonium sulphate. The organic intumescent filler preferably comprises an ammonium phosphate/melamine/pentaerythritol system.

The fabric of the present invention may comprise incompatible organic fibres. These incompatible organic fibres may be organic fibres which will not char intensely over the required temperature range to produce the char bonding. The use of the incompatible organic fibres may help to prevent the fabric of the present invention to remain fire and heat resistant at higher temperatures than it would otherwise do.

The fabric may comprise an amount of organic intumescent filler sufficient to cause the fabric to increase in thickness by at least 20% when exposed to a temperature of at least 500$^{o}$C. Preferably, the increase in thickness is at least 50%.

Any suitable and appropriate type of backing layers and/or facing layers may be employed. The backing layers and/or the facing layers may be provided with a flame retardant material or may be formed of a flame retardant material as may be desired. Where incompatible organic fibres are employed, these may be novoloid or polyaramid fibres.

An embodiment of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Figure 1 is a cross section through a sheet of material for use in forming the fabric of the invention; and

Figure 2 is a cross section through the fabric of the invention using two sheets of material as shown in Figure 1.

Referring to the drawings, there is shown a fabric 2 which is fire and heat resistant and which comprises a laminate of a first sheet of material 4 and a second sheet of material 6. The first and the second sheets of material 4,6 are the same as each other. Figure 1 shows a cross section through the first sheet of material 4 but it will be appreciated that a cross section through the second sheet of material 6 will look exactly the same as that shown in Figure 1.

The first and the second sheets of material 4, 6 are separately formed and then they are connected together.

The first and the second sheets of material 4, 6 each comprise a mixture of an organic intumescent filler and an adhesive which has been applied to a first side 8 of each of the first and the second sheets of material 4, 6 in liquid form. The application is such that the liquid mixture penetrates partially into each of the first and the second sheets of material 4, 6 from the first side 8. On drying, the previously liquid mixture provides each of the first and the second sheets of material 4, 6 with an inner layer 10 formed of just the mixture, an intermediate layer 12 formed of that part of

the first and the second sheets of material 4, 6 that has been penetrated by the mixture, and an outer layer 14 formed of that part of the first and the second sheets of material 4, 6 that has not been penetrated.

As can be seen from Figure 2, the fabric 2 is such that the first and the second sheets of material 4, 6 are positioned with the inner layers 10 touching each other. The inner layers 10 are partially connected together by the adhesive in the mixture.

The first and the second sheets of material 4, 6 are needled by fibres 16 to supplement the connection made by the adhesive.

The adhesive is a resin adhesive. Any suitable and appropriate resin adhesive may be employed. Any suitable and appropriate material for the first and the second sheets of material 4, 6 may also be employed. The first and the second sheets of material are preferably formed from organic fibres which are such that they char within the temperature range of 200-500$^{o}$C, the charring being such that carbonising reactions dominate the thermal degradation that occurs in the organic fibre components.

The fabric 2 may be such that it gives fire and heat resistance up to 1200$^{o}$C. The fabric may be used in aeroplanes, buildings, furniture, road vehicles, protective clothing and in any other suitable and

appropriate areas. Generally, the fabric 2 can be used anywhere where there is a high risk of fire and it is necessary to specify a high performance fabric which is able to act as a fire barrier and to provide heat insulation. The preferred material for the first and the second sheets of material is the VISIL material mentioned above. Such a material gives good char and char bonding, and it releases very low amounts of toxins during combustion. The thread fibres 16 used in the stitch bonding may be any suitable and appropriate type of fibres but they are preferably obtained from VISIL thread or a polyamide thread.

The liquid mixture of the organic intumescent filler and the adhesive may be produced by mixing with water. The liquid mixture may penetrate the first and the second sheets of material 4, 6 by up to 40%. The first and the second sheets of material are then dried and baked to cross link the adhesive. The adhesive acts to bond the organic intumescent filler to the fibres of the first and the second sheets of material 4, 6. The adhesive also acts to provide the tacky inner layers 10 for facilitating the lamination of the first and the second sheets of material 4, 6 together.

When the first and the second sheets of material 4, 6 have been brought together, they are then calendered. The residual tack in the adhesive acts as a pressure

sensitive adhesive to provide a consolidated fabric 2 which is chemically and physically bonded. The consolidated fabric 2 is then lightly needled to provide the fibres 16 and to further consolidate the fabric 2 by providing a mechanical bond.

It is to be appreciated that the embodiment of the invention described above with reference to the accompanying drawings has been given by way of example only and that modifications may be effected. Thus, for example, the invention provides a method of producing the fabric according to the invention, and this method may be the method described above or a different method. Also, the intumescent filler may be an inorganic intumescent filler.

**CLAIMS**

1. A fabric which is fire and heat resistant and which comprises a laminate of first and second sheets of material which have been separately formed and then connected together, the first and the second sheets of material each comprising a mixture of an organic intumescent filler and an adhesive which has been applied to a first side of each of the sheets of material in liquid form such that the liquid mixture penetrates partially into each of the sheets of material from the first side and on drying provides each of the sheets of material with an inner layer formed of just the mixture, an intermediate layer formed of that part of the sheet of material that has been penetrated by the mixture, and an outer layer formed of that part of that sheet of material that has not been penetrated by the mixture, the fabric being such that the first and the second sheets of material are positioned with the inner layers touching each other, and the inner layers being at least partially connected together by the adhesive in the mixture.

2. A fabric according to claim 1 in which the first and the second sheets of material are needled to supplement the connection made by the adhesive.

3. A fabric according to claim 1 or claim 2 in which the adhesive is a resin adhesive.

4. A fabric according to any one of the preceding claims in which the first and the second sheets of material are formed of organic fibres which are such that they char within the temperature range of 100-500$^{o}$C, the charring being such that carbonising reactions dominate the thermal degradation that occurs in the organic fibre components.

5. A fabric according to claim 4 in which the organic fibres are such that they char within the temperature range of 200-500$^{o}$C.

6. A fabric according to claim 4 or claim 5 in which the organic fibres are such that they are flame-retarded organic fibres, or such that they release a flame-retardant on being heated.

7. A fabric according to any one of claims 4 to 6 in which the organic fibres comprise a flame-retarded cotton viscose or wool fibre.

8. A fabric according to any one of the preceding claims in which the first and the second sheets of material are non-woven fabric structures.

9. A fabric according to any one of the preceding claims and including an inorganic fibre component.

10. A fabric according to claims 4 and 9 in which the inorganic fibre component is formed of inorganic fibres which are mixed with the organic fibres.

11. A fabric according to claim 10 in which the fibre is a viscose staple fibre containing silicic acid.

12. A fabric according to any one of the preceding claims in which the organic intumescent material comprises an acid source, a carbonific material, a spumific compound, and a skin-forming soft resin binder to prevent the escape of generated gases from the organic intumescent filler.

13. A fabric according to any one of the preceding claims in which the first and the second sheets of material contain cellulose-based organic fibres, together with a phosphorus-based flame retardant.

14. A fabric according to any one of the preceding claims and comprising incompatible organic fibres.

15. A fabric according to any one of the preceding claims and comprising an amount of organic intumescent filler sufficient to cause the fabric to increase in thickness by at least 20% when exposed to a temperature of at least 500$^{o}$C.

16. A fabric according to any one of the preceding claims and including a backing layer and/or a facing layer.

17. A fabric which is fire and heat resistant, substantially as herein described with reference to the accompanying drawings.

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| **Patents Act 1977**<br>**Examiner's report to the Comptroller under Section 17 (The Search report)** | Application number<br>GB 9419132.7 |
|---|---|
| **Relevant Technical Fields**<br>(i) UK Cl (Ed.N) B5N<br>(ii) Int Cl (Ed.6) B32B 5/24, 5/26, 5/28, 27/04, 27/24, 27/20, 27/18, 7/12<br>**Databases** (see below)<br>(i) UK Patent Office collections of GB, EP, WO and US patent specifications.<br>(ii) ONLINE: WPI, CLAIMS | Search Examiner<br>R J MIRAMS<br>Date of completion of Search<br>6 DECEMBER 1995<br>Documents considered relevant following a search in respect of Claims :-<br>1 TO 17 |

**Categories of documents**

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

| Category | Identity of document and relevant passages | Relevant to claim(s) |
|---|---|---|
| X | US 4372997 A (FRITZE) | 1, 8, 9 |

**Databases:** The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

XP-002269181 

**AN** - EIX87010011555

**TI** - PREDICTING THE THERMAL PROTECTIVE PERFORMANCE OF HEAT-PROTECTIVE FABRICS FROM BASIC PROPERTIES

**AB** - Novel experimental techniques were developed to measure changes in the weight, thickness, density, heat capacity, heat conductivity, and infrared (IR) transmission of protective fabrics occurring during a thermal protective performance (TPP) test. Comparisons are made between polybenzimidazole (PBI), aramid, a PBI/aramid blend fabric, and flame-retardant (FR) cotton fabrics in the 250 g/m<2> (7.5-oz/yd<2>) weight range. This research analyzes changes in fabric heat transfer properties produced through mechanisms of pyrolysis, char formation, and shrinkage. Fiber character is shown to play a decisive role in determining the direction and extent of change in thermophysical properties. Retention of air volume is found to be critical to prolonged thermal protection performance. Experimental data indicate that air and fiber conduction dominate in intense exposures to a mixture of radiant and convective thermal energy; direct radiant transmission is not an important contributor to the total heat transferred in these exposures. (Edited author abstract)

**PUB** - ASTM Spec Tech Publ
- 1986
- ASTM, Philadelphia, PA, USA

**AU** - Shalev Itzhak ; Barker Roger L

**AN** - EIX97123510381

**TI** - Developments in flame retardants for heat and fire resistant textiles - the role of char formation and intumescence

**AB** - Two groups of heat and flame resistant textiles based on the use of non-thermoplastic fibres are reviewed these are: flame retarded cellulosic, wool and man-made fibre containing fabrics, and aromatic and carbonized fibres which forms chars with superior mechanical stabilities compared to the first group. The mechanism and role of char formation are discussed and the incorporation of intumescents in textile materials explored. The combinations of flame retarded char-forming fibers and intumescents give rise to consolidated fibrous char reinforced intumescent char which exhibits enhanced heat and flame resistance compared to individual chars. These interactive combinations offer opportunities for creating high performance barrier textiles.

**PUB** - Polym Degradation Stab; Polymer Degradation and Stability
- Nov-Dec 1996
- Elsevier Science Ltd, Oxford, Engl

**AU** - Horrocks A Richard